Effects of Design Factors on Comprehension Performance with Dynamic Text Display: A Review

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***Abstract*—Communication technology has exploded in the past decade, leading to the question of what the best display method is to deliver electronic text message to public. Dynamic display system is widely used in information communicating medium which includes not only in website design, but also every part of our life such as banks, stock markets, transportation, schools, jewellery shops, restaurants etc. In order to overcome the limitations of screen size of the display units, numerous means of presenting moving materials on dynamic display have been invented. There are many factors that would affect the readability of electronic text. This paper reviews some related empirical studies concerning the various display methods of dynamic text presentation. The factors explored in this review are the text display type, character type, text display direction, and text/background colour-combination. The review would be helpful for researchers in formulating further research plans and methodology for determining the optimum dynamic text display methods on light-emitting diodes (LED) display boards.**

***Index Terms*—Dynamic text display, light-emitting diodes, human performance**

I. Introduction

Electronic information display systems are commonly used in public places such as cinemas, airports, transportation, shopping malls, fast food chain stores etc. Most of these display systems employ cathode ray tubes, liquid crystal displays, gas plasma displays, or light-emitting diodes as the output device. The increase in use of light-emitting diodes (LED) display arouses our interests in the optimizing effective methods of displaying dynamic text. However, in the past, some researchers mainly focused on the studies of dynamic text display on small screens of devices such as cellular phones, pagers and desktop phones [1], [2] and some researches were concerned with the optimal dynamic text display in website design [3]-[6]. A number of studies concerning dynamic message signs (DMSs) used in transportation have been found [7], [8] while no studies have been found on optimal dynamic display using LED display for indoor usages. It maybe an interesting question of what the best display method is to deliver electronic text message for indoor LED displays. LED display simply acts as a display output unit like a computer screen. The text display method, character type, text display direction, text colour etc. can be freely chosen by the designers or operators. Thus the different combinations of the selected factors could affect the readability of electronic text. This paper reviews some related empirical studies concerning the various display methods of dynamic text presentation. The factors explored in this review are the text display type, character type, text display direction, and text/background colour-combination. The review provides a useful summary of important findings on these design factors to human factors researchers for further exploration of the best dynamic text presentation methods on LED displays.

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II. Display type

A. RSVP (Rapid Serial Visual Presentation)

RSVP (rapid serial visual presentation) involves displaying successive words of some textual information at a fixed point on the screen, usually at a predetermined rate and in rapid succession. It was firstly introduced by Forster [9] in a study of the comprehension and processing of written language. The advantage of RSVP was related to the elimination of eye movements, which would lead to a possible reduction in cognitive load [10]. Bernard *et al.* investigated the effect of speed in reading English text with RSVP and found the optimal rate to be about 250 words per minute (wpm) [11]. Wang and Kan performed a dual-task experiment that examined the influence of an RSVP display field on participant comprehension and on reading static and dynamic Chinese text [12]. Their results indicated that the optimal speed for presenting text on an RSVP display was approximately 140 cpm. Nevertheless, in a Chinese RSVP study conducted by Chen and Chien [13], the text was presented either one character or one sentence at a time. The results showed that speeds of 171, 260, and 350 cpm were not associated with significant variation in reading comprehension. Consequently, the optimum speed of RSVP display for reading Chinese text remains uncertain and requires further study. Chen and Chien suggested that different text-flow orientations can be adopted when designing an RSVP display for reading Chinese text and

further studies are necessary to examine the optimum speed of RSVP display for reading Chinese text and the user acquaintance with RSVP displays [14].

B. Leading

Leading display is one of the conventional Internet homepage design methods for presenting dynamic information on visual display terminals (VDTs). The leading display method presents the words by sequence and moves the string of words from right to left. With regards the studies on Chinese leading display, Wang *et al.* pointed out that speed was a significant factor for subjects' searching performance on leading display [5]. Subjects performed better searching in terms of error percentage under 250 than 300 wpm. However, in a leading-display reading study by Wang and Chen [4], the subjects' reading comprehension did not show significant difference under 250 or 300 wpm. In the static and leading display information dual tasks research of Wang *et al.* [3], speed (250 and 300 wpm) of leading display had no significant effect on subjects' searching performance for static display nor on subjects' comprehension for leading display. A recent study by Wang and Kan [12], subjects performed the best comprehension under 195 wpm while subjects did not show significantly different comprehension under 250 and 300 wpm. Jump length of dynamic information characters is another important leading display design factor. The speed of the leading display denotes the amount of information presented within a minute. Jump length, however, signifies the continuity of leading display characters movement. Under the same leading display speed setting, the movement of leading display looks much smoother when the setting of jump length was at a shorter distance. Juola *et al.* [15] showed that reading accuracy was higher for the leading display as jump length increased. Regarding Chinese leading display, Wang *et al.* [5] found that subjects performed better visual performance in searching tasks when the jump length were 0.35 and 0.7 cm.

C. Scrolling

In many researches on scrolling, the speeds of scrolling were always controllable by the operators or designers in which they moved through the document by operating a handle [6] or scroll arrow [16]. However, the fixed display speed method will be employed in our planned research. Regarding the vertical scrolling, text usually moves in a line-by-line manner or scrolls continuously and automatically a raster at a time up from the bottom of the screen. In the study of the optimal methods of presenting dynamic text on different types of screens by Laarni [1], the efficiency for the vertical scrolling improved when the display width increased from 3 to 27.5 cm which implied that the wider the screen, the better the performance will be for vertical scrolling.

III. CHARACTER TYPE

Chinese typography is also a factor that affects visual performance at VDT workstations. Shieh at al. [17] discussed the effect of Chinese typography on users' visual performance with static information. Their results showed that subjects' visual performance (correct percentage) in a quick characters identification task was better when the typography was true type rather than standard Kai type. However, Wang and Chen [4] found that Chinese typography had no significant effect on subjects' reading performance in a leading display study. In comparison with the characters identifications task, the effect of Chinese typography in reading task was relatively lower. Therefore, both of the true and standard Kai types of Chinese typographies can be chosen in the leading display design. Another research done by Chan and Lee [18] showed that traditional Chinese characters of Ming style produced faster reading times and higher preferences than characters of Li style for static information on computer displays.

IV. TEXT DISPLAY DIRECTION

Languages such as Korean, Japanese and Chinese are written in various directions, which are often written horizontally from left to right and sometimes vertically from top to bottom. Thus the text display direction becomes one of the interesting factors investigated in past years. Seo and Lee [19] studied the head-free reading of horizontally and vertically arranged texts in Korean writing and their results showed that reading was 24% faster for horizontally arranged texts, primarily due to larger gaze amplitude for horizontal reading, and thus smaller numbers of saccades and fixations. Another study was conducted by Kajii and Osaka [20] who examined the recognition of briefly presented Japanese words. They found that the performance was better for horizontally displayed Japanese words than for vertically displayed words.

V. TEXT/BACKGROUND COLOUR-COMBINATION

There are some researches that reported text/background of dynamic display had significant effects on users' visual performance. Wang et al. [5] reported that subjects' search error decreased when the text/background colour difference increased. In addition, Wang and Chen [4] found that colour difference was also a significant factor in subjects' reading performance at a leading display. Subjects' reading performance for the color combinations with higher color difference (black-on-white, white-on-black, and blue-on-yellow) was significantly better than that with lower color difference (red-on-white, blue-on-white, and green-on-white). A recent study by Wang et al. [7] on enhancing messages displayed on dynamic message sign showed that amber-colored messages resulted in the shortest response time and subjects took longer time to respond to red-colored messages.

On visual display terminals, luminance contrast between the text and background colors is an important factor in text/background color combination. Shieh and Lin [21] indicated that visual identification performance and subjective preference increased as the luminance contrast of text/background color combination became greater. Moreover, color can provide an additionally subjective benefit by making display work more pleasant. Thus, many

text/background color combinations are used to attract users and to increase the attractiveness of a homepage. Besides, Shieh and Chen [22] reported that subjects' viewing distance was significantly affected by color combination.

VI. Summary

In summary, three common types of dynamic text display methods used for dynamic text display were studied by researchers in recent decades: RSVP, leading, and scrolling. Specific design factors such as character types, text display direction, and text/background color combinations were also studied for the optimal display and better reading performance. However, most researchers mainly focused on the studies of dynamic text display on small screens of cellular phones, pagers and desktop phones and some researches were concerned with the optimal dynamic text display in website design. So far, no studies were found on indoor LED display board for optimal display method. Thus, this review should be helpful in providing information for formulating further research plans and methodology and establishing the hypotheses for determining the optimum dynamic text display methods on LED display boards.

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